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13. ABSTRACT (Maximum 200 words)

In the past three years, we have already conducted theoretical and experimental studies of some naturally occurring ionospheric disturbances. Periodic amplitude variations of satellite beacon signals were observed as the precursors of the plumes of equatorial ionospheric irregularities. Some outstanding features of explosive spread F reported in Woodman and La Hoz' and Woodman and Kudeki can be reasonably understood in terms of the lightning induced electromagnetic effects. The spectral broadening of monochromatic VLF radio signals detected by satellites in the topside ionosphere was attributed to the nonlinear scattering of waves off ionospheric density irregularities. Furthermore, the irregularity anisotropy can give rise to prominent effects on the Faraday polarization fluctuations of linearly polarized radio signals. This fact can be based on to develop the radio diagnostics of the anisotropic nature of ionospheric irregularities, namely, to determine the geometry of field-aligned density irregularities. Efforts were also made on the reduction of ionospheric effects on the polarization measurements during satellite tracking.

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Final Report on the Sponsored Research on "Sources and Causes
of Upper Atmospheric Disturbances" (AFOSR-88-0217)

Principal Investigator: Min-Chang Lee

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In the past three years, we have already conducted theoretical and experimental studies of some naturally occurring ionospheric disturbances. Periodic amplitude variations of satellite beacon signals were observed as the precursors of the plumes of equatorial ionospheric irregularities [Klobuchar and Lee, 1989]. Some outstanding features of explosive spread F reported in Woodman and La Hoz [1976] and Woodman and Kudeki [1984] can be reasonably understood in terms of the lightning induced electromagnetic effects [Liao, Freidberg, and Lee, 1989]. The spectral broadening of monochromatic VLF radio signals detected by satellites in the topside ionosphere was attributed to the nonlinear scattering of waves off ionospheric density irregularities [Groves, Lee, and Kuo, 1988]. Furthermore, the irregularity anisotropy can give rise to prominent effects on the Faraday polarization fluctuations of linearly polarized radio signals [Lee, Nghiem, and Yoo, 1989]. This fact can be based on to develop the radio diagnostics of the anisotropic nature of ionospheric irregularities, namely, to determine the geometry of field-aligned density irregularities [Lee, 1991]. Efforts were also made on the reduction of ionospheric effects on the polarization measurements during satellite tracking [Yoo and Lee, 1990].

Our recent research centers on the investigation of intense radar backscatter echoes from the topside ionosphere observed at the Millstone Hill (Massachusetts) and lately at Tromso (Norway) [Groves, Lee, and Foster, 1990]. More morphology study of this phenomenon needs to further confirm the reality of it as a topside ionospheric process

[Groves, Ph.D. thesis, 1991]. Under this AFOSR sponsored program, three students have accomplished their thesis work. Their thesis topics are, respectively, "Nonlinear Ionospheric Propagation Effects on UHF and VLF Radio Signals" by K.M. Groves [Ph.D. Dissertation, 1991], "Ionospheric Plasma Disturbances Caused by the Lightning Produced Electromagnetic Effects" by C.P. Liao [M.S. Thesis, 1989], and "Depolarization and Magnetoionic Mode Coupling of Radio Waves in the Ionosphere" by C. Yoo [B.S. Thesis, 1989].

The afore-mentioned research effort leads to the following publications:

- (1) J.A. Klobuchar and M.C. Lee, "Periodic amplitude variations as precursors of plumes of equatorial ionospheric irregularities", *J. Atmos. Terr. Phys.*, 51, 733, 1989.
- (2) C.P. Liao, J.P. Freidberg and M.C. Lee, "Explosive spread F caused by lightning-induced electromagnetic effects", *J. Atmos. Terr. Phys.*, 51, 751, 1989.
- (3) M.C. Lee and J.A. Klobuchar, "Faraday polarization fluctuations of satellite beacon signals", in *Investigation of the ionosphere by means of beacon satellite measurement*, edited by Cao Chong, pp 145-150, Pergamon Press, 1988.
- (4) K.M. Groves, M.C. Lee and S.P. Kuo, "Spectral broadening of VLF radio signals traversing the ionosphere", *J. Geophys. Res.*, 93, 14683, 1988.
- (5) M.C. Lee, S.V. Nghiem and C. Yoo, "Effects of irregularity anisotropy on Faraday polarization fluctuations", *J. Geophys. Res.*, 94, 15421, 1989.
- (6) C. Yoo and M.C. Lee, "Reduction of ionospheric effects on polarization measurements during satellite tracking", *Proc. Ionospheric Effects Symposium*, Springfield, Virginia, 1990.
- (7) K.M. Groves, M.C. Lee and J.C. Foster, "UHF radar backscatter enhancements

from the topside ionosphere", *Proc. Ionospheric Effects Symposium*, Springfield, Virginia, 1990.

(8) K.M. Groves, "Plasma dynamics in both artificial-induced and naturally occurring depleted ionospheric regions", Ph.D. Dissertation, MIT, 1991.

(9) C.P. Liao, "Ionospheric plasma disturbances caused by the lightning induced electromagnetic effects", M.S. thesis, MIT, 1989.

(10) C. Yoo, "Depolarization and magnetoionic mode coupling of radio waves in the ionosphere", B.S. thesis, MIT, 1989.

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